DroMOOC

Sensor fusion and state estimation

Basic Level

Motivations for sensor fusion

Sylvain BERTRAND

ONERA

ONERA THE FRENCH AEROSPACE LAB

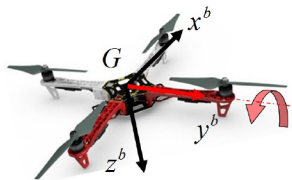
CentraleSupélec

ENSTA ParisTech

université PARIS-SACLAY

Motivations for sensor fusion

- Basics on sensors and measurements
- Example of quadrotor pitch angle estimation
  - from measurements by a single sensor
  - from combination of measurements by several sensors

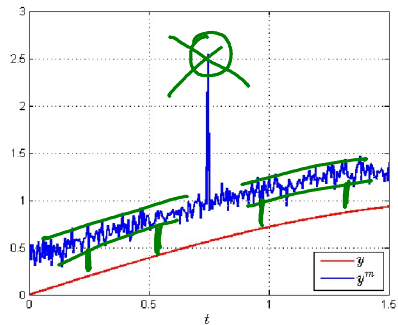


Sensors and measurements

- Simple sensor model:

$$y^m(k) = s.y(k) + n(k) + b$$

  - k: discrete-time index such that $t = k.T_s$ with sampling period T_s
  - s: scale factor
  - $n(k)$: measurement noise
  - b: bias



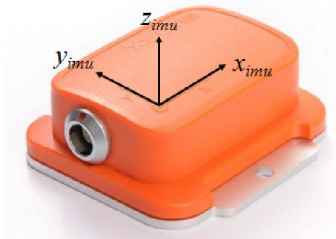
Sensor fusion

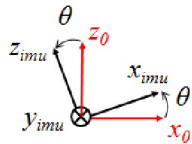
Improve estimation process by combining measurements from different (types of) sensors

- compensate for drawbacks of some sensors by advantages of some others
  - noise/bias
  - accuracy/frequency
- improve robustness
  - wrt loss of sensors
  - wrt perturbations (environment)

A simple example

- Estimation of quadrotor pitch angle from IMU measurements (3 axis accelerometer and rate gyro)

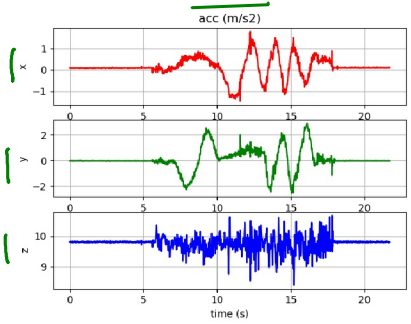


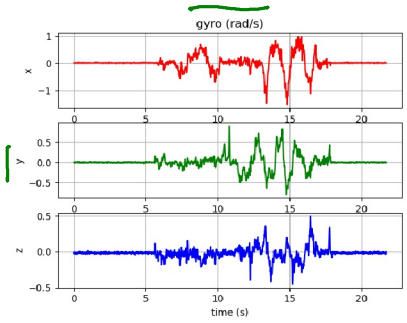


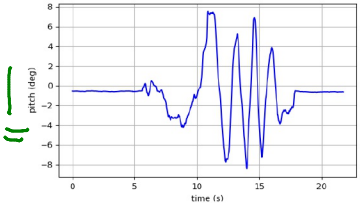
- Assumptions: (quasi-stationary flight)
  - Small angles and low accelerations
  - Accelerometer can be used as inclinometer

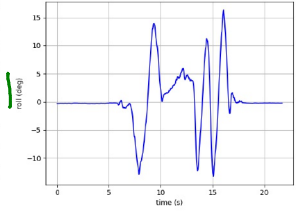
A simple example

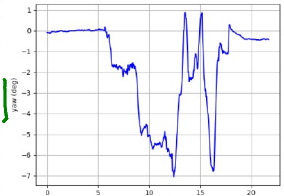
- Measurements and reference







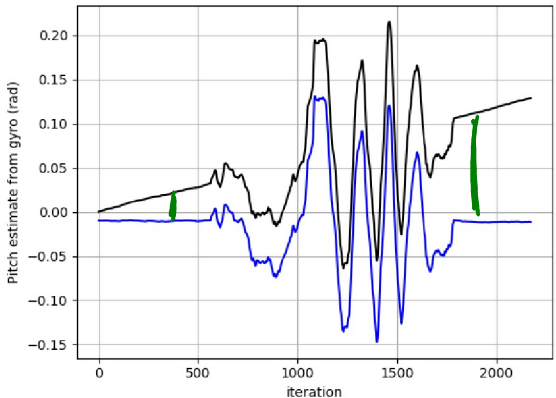




A simple example (cont'd)

- Estimation of quadrotor pitch angle from rate gyro measurements only

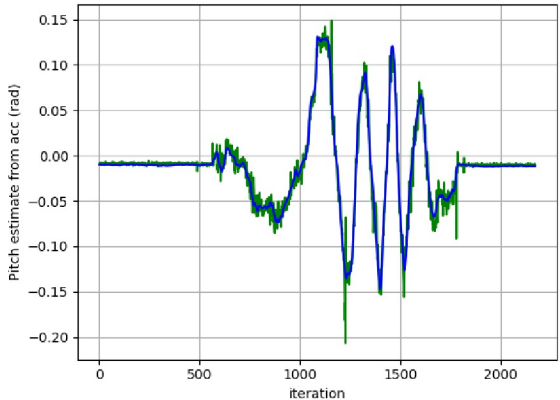
$$\frac{d}{dt}\theta^m_{Gyr}(t) = GYR^m_y(t) = \omega_y(t) + n(t) + b$$



A simple example (cont'd)

- Estimation of quadrotor pitch angle from accelerometer measurements only

$$\theta^m_{Acc} = \arctan\left(\frac{-ACC^m_x}{\sqrt{(ACC^m_y)^2 + (ACC^m_z)^2}}\right)$$



A simple example (cont'd)

- Estimation of quadrotor pitch angle by fusing measurements from rate gyro and accelerometer (using a Kalman Filter)
- Bias of rate-gyro is simultaneously estimated